Ice-Covered Lakes in Gale Crater Mars: The Cold and Wet Hypothesis

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Recent geological discoveries from the Mars Science Laboratory provide evidence that Gale crater may have intermittently hosted a fluvio-lacustine environment during the Hesperian, with individual lakes lasting for a period of tens to hundreds of thousands of years. (Grotzinger et al., Science, 350 (6257), 2015). Estimates of the CO2 content of the atmosphere at the time the Gale sediments formed are far less than needed by any climate model to warm early Mars (Bristow et al., Geology, submitted), given the low solar energy input available at Mars 3.5 Gya. We have therefore explored the possibility that the lakes in Gale during the Hesperian were perennially covered with ice using the Antarctic Lakes as an analog. Using our best estimate for the annual mean surface temperature at Gale at this time (~230K) we computed the thickness of an ice-covered lake. These thickness range from 10-30 meters depending on the ablation rate and ice transparency and would likely inhibit sediments from entering the lake. Thus, a first conclusion is that the ice must not be too cold. Raising the mean temperature to 245K is challenging, but not quite as hard as reaching 273K. We found that a mean annual temperature of 245K ice thicknesses range from 3-10 meters. These values are comparable to the range of those for the Antarctic lakes (3-6 m), and are not implausible. And they are not so thick that sediments cannot penetrate the ice. For the ice-covered lake hypothesis to work, however, a melt water source is needed. This could come from subaqueous melting of a glacial dam in contact with the lakes (as is the case for Lake Untersee) or from seasonal melt water from nearby glaciers (as is the case for the Dry Valley lakes). More work is needed to better assess these possibilities. However, the main advantage of the ice-covered lake model (and the main reason we pursued it) is that it relaxes the requirement for a long-lived active hydrological cycle involving rainfall and runoff, which no climate model is able to produce given known constraints on the early Mars environment.